International Journal of Research in Agronomy 2024; SP-7(3): 337-346

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(3): 337-346
Received: 08-01-2024
Accepted: 12-02-2024

Shaziya KL
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Bangalore, Karnataka, India

Hundekar ST
AICRP on Agroforestry, MARS, UAS, Dharwad, Karnataka, India

Hanumanta D Lamani
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Bangalore, Karnataka, India

Vinutha BB
Department of Agronomy, College of Agriculture, UAS, Bangalore, Karnataka, India

Corresponding Author:
Shaziya KL
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Bangalore, Karnataka, India

Growth, yield and soil nutrient status of Byadgi chilli (*Capsicum annuum* L.) as influenced by foliar application of cow urine in a *Vertisol*

Shaziya KL, Hundekar ST, Hanumanta D Lamani and Vinutha BB

DOI: https://doi.org/10.33545/2618060X.2024.v7.i3Se.473

Abstract
A field experiment was conducted during *kharif* 2018 in the farmer's field at Agadi village (Tq: Hubballi) in Dharwad district to study the "Growth, yield and soil nutrient status of Byadgi chilli (*Capsicum annuum* L.) as influenced by foliar application of cow urine in a *Vertisol*". Experiment consisted of 12 treatments with three replications laid out in Completely Randomized Block Design. Treatment received two foliar application of 15 Percent cow urine one each at 60 and 90 DAT recorded highest plant height and number of branches at 75 DAT, 90 DAT and at harvest of byadgi chilli. 15 Percent cow urine one each at 60 and 90 DAT recorded highest fruit yield (14.07 q ha^{-1}) which was on par with two foliar applications at 10 Percent (13.06 q ha^{-1}). After harvest of the crop, Control (water spray) recorded highest available nitrogen, phosphorus, Sulphur and exchangeable Magnesium content of 253.49 kg ha^{-1}, 33.56 kg ha^{-1}, 30.13 kg ha^{-1} and 6.43 cmol (p +) kg^{-1}, respectively. Treatment with 10 Percent cow urine spray at 60 + 90 DAT recorded highest available K of 323.43 kg ha^{-1} and 5 Percent cow urine spray at 60 + 90 DAT recorded highest exch. calcium of 18.60 cmol (p +) kg^{-1} in soil.

Keywords: Cow urine, growth, fruit yield

Introduction

Byadgi Chilli is a long duration (180 to 210 days) and indeterminate crop requires timely manuring particularly at grand growth (60-75 DAT) and fruit development (90-105 DAT) stages. Chilli plants should have adequate supply of nitrogen during fruit development to enhance its yield. But, the conventional nitrogen fertilizers applied to soil as basal dose during transplanting and top dressed after 45 DAT are subjected to leaching, volatilization and run off losses leaving very little nitrogen available during fruit development. This results in lesser yield in chillies. In order to meet the timely and immediate requirement of nitrogen, foliar application of nitrogen through urine in addition to top dressing of urea is very essential. On an average about 13.0 litres of urine will be excreted by a cow in a day. This urine gets lost due to percolation, evaporation and runoff in cattle shed if the floor of cattle shed is of ordinary type particularly during rainy season, the volume of urine excreted by cow will be more. Hence urine excreted by farm animals can be used as source of nutrient for foliar spray after proper dilution with water. Analysis of cow urine revealed that, it is neutral in reaction (pH 7.10) and soluble salt content is 6.55 dS/ m. It contains 0.31 Percent N, 20 mg L^{-1} P, 0.93 Percent K, 72 mg L^{-1} of Ca + Mg. Thamhane *et al*. (1965) [20] reported that, cow urine contains 1 Percent N, 1.9 Percent K_2O and traces of P_2O_5 which can be used as source of liquid fertilizer. Besides it contains oxalic acid, hipuric acid, crietinine, eltine, enzymes, steroids, propiline oxide, ethylene oxide, glycosides, glucose, citric acid, alkalide, acetate, endesonine, carbolic acid and growth promoting substances (Janjal *et al*. 2021) [8]. Foliar spray of cow urine at flowering and fruit development stages in chilli may significantly enhance fruit yield. Very little information is available about the foliar spray of cow urine as a source of nutrients in influencing the yield. Hence the present study was planned.

Materials and Methods

A field experiment was conducted during *kharif* 2018 in the farmer's field (Survey No. 88) at Agadi village (Tq., Hubballi) in Dharwad district. The soil of the experimental site is *Typic Chromustert*.

Soil of the experimental site is clay in texture, neutral in pH (7.40), normal in soluble salts (0.26 dS/m), medium in organic carbon (6.90 g kg^{-1}), low in avail. nitrogen (188.65 kg ha^{-1}) and phosphorus (19.85 kg ha^{-1}), medium in potassium (290.50 kg ha^{-1}) and high in avail. sulphur (22.00 kg ha^{-1}). Cow urine was collected from a selected animal and analysed for its nutrient content and reaction (pH) and TSS content. The concentration of diluted cow urine solution fixed for foliar spray is based on TSS content of solution as indicated by EC values. It was observed that, 4, 6, 8, 10, 12, 14, 15 and 20 Percent solutions of cow urine after dissolving in bore well water recorded TSS contents of 0.84, 0.95, 1.06, 1.14, 1.27, 1.46, 1.56 and 2.43 dS m^{-1} respectively. Based on the critical limit of total salt content in spray solution as given by CSSRI, Karnal as 2 dS m^{-1}, fifteen Percent solution of cow urine was taken as upper limit. Based on the peak requirement of nutrients to chilli crop, time and frequency of foliar sprays were fixed as 60 and 90 days after transplanting (DAT). The treatments details are furnished in Table-1. All the treatments received uniform dose of recommended fertilizers (100:50:50 N, P_2O_5, K_2O Kg ha^{-1}) along with FYM of 25 tonnes ha^{-1}. 45 days old chilli seedlings were transplanted at 75 cm X 75 cm spacing on 29/ 07/ 2018. Completely matured red fruits were harvested in two stages, first on 10/ 01/ 2019 and second on 30/ 01/ 2019. These red fruits were sundried and yield was recorded by pooling the fruits of two pickings and expressed in quintals per hectare.

Table 1: Treatment details

T_1	Control (Water spray at 60 & 90 DAT)
T_2	5% cow urine spray at 60 DAT
T_3	10% cow urine spray at 60 DAT
T_4	15% cow urine spray at 60 DAT
T_5	5% cow urine spray at 90 DAT
T_6	10% cow urine spray at 90 DAT
T_7	15% cow urine spray at 90 DAT
T_8	5% cow urine spray at 60 & 90 DAT
T_9	10% cow urine spray at 60 & 90 DAT
T_{10}	15% cow urine spray at 60 & 90 DAT
T_{11}	1% urea spray at 60 DAT
T_{12}	50 ppm NAA spray at 60 DAT

Note: RPP (Recommended Package of Practices) for chilli is 100:50:50 N, P_2O_5, K_2O Kg ha^{-1} + FYM 25 tonnes ha^{-1} is common for all the treatments.

Observations recorded

Growth parameters: Plant height, number of branches and dry matter yield per plant were recorded at 60, 75, 105 DAT and at harvest.

Plant height

Plant height was measured from the base of the plant to the growing tip by holding the plants vertically in randomly selected five plants. The mean plant height was expressed in centimeter (cm).

Number of branches per plant

Number of secondary branches were counted in randomly tagged five plants at 60, 75, 105 DAT and at harvest. Average was computed to get number of branches per plant.

Dry mater yield per plant

Two chilli plants were randomly selected in each treatment at 60, 75, 105 DAT and at harvest and cut to the ground level. The fruits were separated from shoot and both the components were air dried followed by drying in hot air oven at 65-70 °C to get constant weight. The oven dry weight was recorded and expressed in grams per plant.

Yield parameters

Number of fruits per plant per picking

Number of red matured fruits per plant was counted from five randomly selected plants in the net plot area at each picking stage and average was worked out. Altogether there were two pickings.

Dry weight of 100 chilli fruits

Red ripe fruits harvested from the net plot area were sundried for 15 days till they become brittle. Fruits from all the three pickings were pooled to get composite sample. One hundred fruits were randomly selected from each treatment and their weight was recorded.

Dry chilli yield per hectare

Based on the net plot yields, yield per hectare was calculated and expressed in quintals.

Physical properties of chilli fruits

L/B ratio

Ten sun dried fruits were collected randomly from the composite sample at the time of final picking of chilli. Fruit length was measured in centimeter from base to tip of the fruit excluding pedicel. Breadth was measured at the base of the fruit and expressed in centimeter (cm). L/B ratio was calculated (Pankar and Magar, 1978) [11].

Percent Seed, Pericarp and Pedicel

Ten oven dried red chilli fruits which were weighed to a constant weight were partitioned carefully into seeds, pericarp and pedicel. These individual components were weighed separately and percentage was calculated by using the formula (Pankar and Magar, 1978) [11].

$$\text{Percent Component} = \frac{\text{Weight of individual component (g)}}{\text{Total weight of whole fruit (g)}} \times 100$$

Moisture Percent of fresh fruits

At peak picking stage, freshly harvested red ripe fruits (10 Nos) of different treatments were collected and transferred to wet muslin cloth bag. After recording initial weight, they were air dried in shade for 2-3 days and then transferred to hot air oven for oven drying at 50 °C for 12 hours or more till constant weight is obtained. The loss in weight recorded between fresh fruits was taken as moisture content of freshly harvested fruits and expressed in percentage (Pankar and Magar, 1978) [11].

Collection and Preparation of Soil Samples

Soil samples were collected from a depth of 0-20 cm from each treatment after the final picking stage. The collected soil samples were shade dried, grinded in wooden pestle and mortar, sieved (2 mm) and mixed thoroughly to get a composite soil sample for analysis.

Analysis of soil samples: Details of the methods followed are given in Table 2.

Table 2: Methods employed for the analysis of soil samples

Sl. No.	Properties	Methods employed	Reference
Soil analysis			
A. Physical properties			
1.	Particle size analysis	Hydrometer method	Piper (2002) [12]
2.	Bulk density	Clod method	Black (1965) [3]
3.	Particle density	Pycnometer method	Piper (2002) [12]
4.	Max. water holding capacity	Keen Raczkowoski brass cup method	Piper (2002) [12]
B. Chemical properties			
1.	pH_w (1:2.5 soil water suspension)	Potentiometric method	Sparks (1996) [17]
2.	Electrical conductivity (1:2.5 soil water extract)	Conductometric method	Sparks (1996) [17]
3.	Free lime	Acid neutralization method	Piper (2002) [12]
4.	Organic carbon	Walkley and Black's wet oxidation method	Sparks (1996) [17]
C. Fertility status			
1.	Available nitrogen	Alkaline potassium permanganate method	Subbaiah and Asija (1956) [18]
2.	Available phosphorus	$NaHCO_3$ extraction followed by spectrophotometric method	Sparks (1996) [17]
3.	Available potassium	1N Ammonium acetate extraction followed by flame photometry	Sparks (1996) [17]
4.	Available sulphur	$CaCl_2.2H_2O$. extraction followed by turbidimetry method	Sparks (1996) [17]
5.	Exch. Ca and Mg	1N Ammonium acetate extraction followed by complexometric titration method	Jaiswal (2013) [7]

Table 3: Initial physical and chemical properties of the soil of experimental site

Sl. No.	Particulars	Values
I.	**Physical properties**	
1.	Particle size distribution (Percent oven dry basis)	
	Sand	22.05
	Silt	18.55
	Clay	59.40
2.	Textural class	Clay
3.	Bulk density (Mg m^{-3})	1.28
4.	Particle density (Mg m^{-3})	2.62
5.	Maximum water holding capacity (%)	61.15
II.	**Chemical properties**	
1.	Soil pH (1:2.5 soil water suspension)	7.40
2.	EC (dS m^{-1}) (1:2.5 soil water extract)	0.26
3.	Organic carbon (g kg^{-1})	6.90
5.	Free $CaCO_3$ (%)	3.56
6.	Available Nitrogen (kg ha^{-1})	188.65
7.	Available Phosphorus (P_2O_5 kg ha^{-1})	19.85
8.	Available Potassium (K_2O kg ha^{-1})	290.5
9.	Available Sulphur (kg ha^{-1})	22.0
10.	Exchangeable Calcium (cmol (p^+) kg^{-1})	17.72
11.	Exchangeable Magnesium (cmol (p^+) kg^{-1})	5.50
12.	**DTPA extractable micronutrients (mg kg^{-1})**	
i.	Zinc	0.61
ii.	Copper	0.80
iii.	Iron	1.30
iv.	Manganese	1.65

Table 4: Methods employed for the analysis of cow urine samples

S. No.	Properties	Methods employed	Reference
1.	pH	Potentiometric method	Sparks (1996) [17]
2.	Electrical conductivity	Conductometric method	Sparks (1996) [17]
3.	Nitrogen	Micro Kjeldhal method with H_2SO_4 digestion	Tandon (1998) [19]
4.	Phosphorus	Diacid digestion followed by vanado molybdophosphoric yellow colour method	Tandon (1998) [19]
5.	Potassium	Diacid digestion followed by flame photometer method	Tandon (1998) [19]
6.	Sulphur	Diacid digestion followed by turbidimetry method	Tandon (1998) [19]
7.	Calcium and Magnesium	Diacid digestion followed by versenate titration method	Jaiswal (2013) [7]
8.	Chloride	Precipitation titration method	(Gupta, 2007) [4]
9.	Carbonates and bicarbonates	Neutralization titration method	(Gupta, 2007) [4]
10.	Micronutrient cations	Atomic absorption spectrophotometer	(Gupta, 2007) [4]

Table 5: Composition of cow urine

Parameters	Values
Moisture (%)	93.67
Specific gravity (g/cc)	1.05
Refractive index	1.34
pH	7.10
TSS (dS/m)	6.55
Chloride (mg/lit)	356
Carbonates (mg/lit)	1500
Bicarbonates (mg/lit)	7065
Uric acid (mg/lit)	240
Total nitrogen (%)	0.31
Phosphorus (%)	0.002
Potassium (%)	0.93
Sulphur (%)	0.0025
Calcium (mg/lit)	50.00
Magnesium (mg/lit)	22.20
Zinc (mg/lit)	0.11
Copper (mg/lit)	0.65
Iron (mg/lit)	0.61
Manganese (mg/lit)	0.067
Microbiological analysis	
Bacterial count (cfu/ ml)	21×10^5
Actinomycetes count (cfu/ ml)	1×10^2

Table 6: Quantity of nitrogen, phosphorus, potassium and Sulphur sprayed through cow urine

Concentration	Nitrogen (kg ha^{-1})			Phosphorus (g ha^{-1})			Potassium (kg ha^{-1})			Sulphur (g ha^{-1})		
	60 DAT	90 DAT	60 & 90 DAT	60 DAT	90 DAT	60 & 90 DAT	60 DAT	90 DAT	60 & 90 DAT	60 DAT	90 DAT	60 & 90 DAT
5% Cow urine	1.26	1.90	3.17	37.36	56.17	93.80	3.78	5.72	9.51	46.70	70.22	117.26
10% Cow urine	2.52	3.81	6.34	74.72	112.36	187.62	15.70	11.45	19.02	93.40	140.45	234.53
15% Cow urine	3.81	5.72	9.54	112.08	168.53	281.71	11.45	17.18	28.63	140.10	210.67	352.14
1% Urea	2.38	--	--									
Control	--	--	--									

Results and Discussion

Plant height

Before foliar spray, no significant difference was noticed between treatments with respect to plant height at 60 DAT. This is obvious because, all treatments received foliar spray of cow urine on 60 DAT. Further, all treatments received uniform dose of RDF (Table 7). Hence, there was no effect of cow urine spray on plant height at 60 DAT. Similar results of foliar application of Ca $(NO_3)_2$ and 19:19:19 as well as KNO_3 water soluble fertilizers on plant height of Byadgi chilli at 60 DAT were reported by Jadhav (2017) [5].

At 75, 105 and at harvest, significant differences existed among the treatments which received cow urine foliar spray. Treatment (T_{10}) (77.00, 84.10 and 85.60 cm at 75, 105 and 140 DAT, respectively) recorded highest plant height which received two foliar sprays of 15 Percent cow urine at 60 + 90 DAT while, lowest was observed in control (49.27, 69.17 and 72.47 cm respectively) that was followed by treatments T_2 (75 DAT), T_5 (105 DAT) and T_{12} (harvest) which recorded 54.33, 69.48 and 75.60 cm, respectively. The foliar sprays given on 60th and 90th DAT closely synchronized with grand growth stage which might have increased the metabolic activity in plants leading to cell elongation contributing to increased plant height. The cow urine supplied through foliar spray at these stages might have been better absorbed by foliage through cuticle which led to increased plant growth as amide form of nitrogen supplied through cow urine is directly involved in cell division that might have caused increased vegetative growth because nitrogen is an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. Critical examination of the data also revealed that, two sprays of cow urine recorded higher plant height than single spray. This which might be due to repeated spray and more availability of nutrients particularly nitrogen directly to the required sites on plant canopy. Besides amide nitrogen, other growth promoting substances present in cow urine might have enhanced cell elongation leading to increased plant height. Further chilli is an indeterminate and long direction crop requires N constantly supply to put forth vegetative growth. Sadhukhan *et al.* (2019) [14] reported that, foliar spray of cow urine has resulted in increased plant height in paddy. Similarly, the values of plant height obtained in the present investigation closely agree with the values reported earlier by Janjal *et al.* (2021) [8] in maize. Increased concentrations of cow urine spray have resulted in increased plant height at all days except at 60 DAT. This is because greater supply of all nutrients along with growth promoting substances present at higher concentration than at lower concentration.

Table 7: Effect of foliar spray of cow urine on plant height of chilli at different days (Cv. Dyavnur)

Treatments	Plant height (cm)			
	60 DAT	75 DAT	105 DAT	Harvest
T_1 - Control (Water spray at 60 & 90 DAT)	43.87	49.27	69.17	72.47
T_2 - 5% cow urine spray at 60 DAT	49.87	54.33	76.80	84.47

T_3 - 10% cow urine spray at 60 DAT	43.83	59.33	83.00	83.73
T_4 - 15% cow urine spray at 60 DAT	53.47	69.33	83.78	85.20
T_5 - 5% cow urine spray at 90 DAT	47.87	58.00	69.48	81.87
T_6 - 10% cow urine spray at 90 DAT	53.90	57.47	73.92	80.13
T_7 - 15% cow urine spray at 90 DAT	57.67	65.80	79.03	86.40
T_8 - 5% cow urine spray at 60 & 90 DAT	47.90	58.67	74.37	76.03
T_9 - 10% cow urine spray at 60 & 90 DAT	52.20	54.47	74.57	82.93
T_{10} - 15% cow urine spray at 60 & 90 DAT	48.33	77.00	84.10	85.60
T_{11} - 1% urea spray at 60 DAT	52.13	57.27	74.74	79.00
T_{12} - 50 ppm NAA spray at 60 DAT	51.93	55.13	69.27	75.60
S.Em. ±	0.98	3.25	4.19	2.32
C.D. (0.05)	NS	9.55	12.29	6.80
C.V. (%)	3.67	10.25	10.34	5.37

DAT - Days after transplanting
RDF - 100:50:50 N, P_2O_5 and K_2O kg ha^{-1}, respectively + FYM (25 t ha^{-1}) is common for all the treatments NS Non-significant

Number of branches

Data presented in Table 8 indicated that, foliar application of cow urine has non-significant effect on the plant height of chilli at 60 DAT. At 75, 105 and harvest, significant difference existed among the treatments which received cow urine foliar spray. Treatment T_{10} (12.00, 16.43 and 19.67 at 75, 105 and 140 DAT, respectively) recorded highest number of branches which received two foliar sprays of 15 Percent cow urine at 60 + 90 DAT. while, lowest was observed in control T_1 (9.93, 12.52 and 13.57 at 75, 105 and harvest respectively) which was followed by treatment T_{12} (10.13, 12.80 and 14.87 at 75, 105 & 140 DAT, respectively).

Comparison between the treatments that received 5, 10 and 15 Percent foliar spray of cow urine, it was noticed that, all the treatments (T_4, T_7 & T_{10}) which received 15 Percent foliar spray of cow urine recorded numerically higher number of branches than treatments which received 5 and 10 Percent foliar spray. Data also revealed that, irrespective of concentrations, treatments (T_8, T_9 & T_{10}) which received two foliar spray of cow urine recorded higher number of branches than treatments that received one foliar spray of cow urine. Treatments which received urea spray (T_{11}) and NAA spray (T_{12}) recorded numerically lower number of branches than treatments with urine spray.

Higher concentrations of nitrogen, phosphorus, and other growth-promoting substances provided at an early stage through 15% foliar spray have improved photosynthetic activity, and photosynthates may have been used to produce more auxiliary buds, resulting in more branches. Further phosphorus present in cow urine could have been directly absorbed by the plant canopy, which played a part in cell division and cell growth leading to more branches. Regardless of the time of foliar spray, treatments getting 15% foliar spray reported considerably more branches than 5% and 10% foliar spray medicines. This is due to greater nutrient concentration in foliar spray of 15%. Data also disclosed that two foliar sprays produced more branches than a single spray regardless of concentration. This was due to the presence of nitrogen (0.31%), phosphorus (0.002%) and calcium (50 mg / lit) nutrients in cow urine that assist in cell division and cell growth leading to greater branch numbers. In addition, chilli is an indeterminate crop and the nutrients (especially N, P & Ca) provided by foliar spray at 60 and 90 DAT may have synchronized with maximum crop demand resulting in more branches. The results are in close agreement with Jadhav (2017) [5] findings in chilli and Jadhav *et al.* (2020) [6] in maize. The number of branches recorded in this experiment is in agreement with Veerendra Patel (2014) [21], which indicated that the amount of branches in chilli increased owing to enhanced concentration of mono potassium phosphate foliar spray.

Table 8: Effect of foliar spray of cow urine on number of branches of chilli at different days (Cv. Dyavnur)

Treatments	No. of branches plant^{-1}			
	60 DAT	**75 DAT**	**105 DAT**	**Harvest**
T_1 - Control (Water spray at 60 & 90 DAT)	9.20	9.93	12.52	13.57
T_2 - 5% cow urine spray at 60 DAT	8.93	10.67	13.18	15.64
T_3 - 10% cow urine spray at 60 DAT	9.00	10.87	13.47	15.73
T_4 - 15% cow urine spray at 60 DAT	9.60	11.47	14.13	17.75
T_5 - 5% cow urine spray at 90 DAT	9.10	10.20	14.12	16.96
T_6 - 10% cow urine spray at 90 DAT	9.47	10.67	14.42	17.95
T_7 - 15% cow urine spray at 90 DAT	10.00	10.93	14.95	18.08
T_8 - 5% cow urine spray at 60 & 90 DAT	9.43	10.87	15.20	18.97
T_9 - 10% cow urine spray at 60 & 90 DAT	9.37	11.53	16.10	19.55
T_{10} - 15% cow urine spray at 60 & 90 DAT	8.63	12.00	16.43	19.67
T_{11} - 1% urea spray at 60 DAT	8.73	10.53	13.32	15.57
T_{12} - 50 ppm NAA spray at 60 DAT	8.73	10.13	12.80	14.87
S.Em. ±	0.62	0.36	0.83	0.92
C.D. (0.05)	NS	1.06	2.44	2.71
C.V. (%)	11.77	5.80	10.15	10.91

DAT - Days after transplanting
RDF - 100:50:50 N, P_2O_5 and K_2O kg ha^{-1} respectively + FYM (25 t ha^{-1}) is common for all the treatments NS – Non-significant

Physical characteristics of chilli fruits

Cow urine foliar spray had no important impact on moisture percentage, L/ B ratio, percent pericarp, seed content, and pedicel content (Table 9). The partitioning of the entire fruit into pericarp, seed and pedicel components revealed that in all treatments, pericarp weight was comparatively greater than seed component. The pedicel weight is minimum and it was only 6.98%. Higher pericarp weight than seed in cow urine foliar spray treatments was due to higher nutrient absorption by foliage resulting in enhanced photosynthesis. In addition, photosynthates were more partitioned into pericarp portions that add to quality attributes. Pungency, colour, ascorbic acid and oleoresins are discovered to be extremely concentrated in the part of the pericarp and absence of these characteristics for seeds (Pankar and Magar, 1978) [11]. Similar observations were recorded by Natarajan (1990) [9] for few varieties of chillies grown in Kerala. It appears that in altering these physical attributes, foliar spray of cow urine at either 60 or 90 DAT and also in different concentrations has little impact. These physical characteristics can be found to be genetically controlled and the application of nutrients to soil or foliage has restricted impact on physical characteristics. Results on seed, pericarp and pedicel elements are in close agreement with Bidari (2000) [2].

Table 9: Effect of foliar spray of cow urine on physical characteristics of red chilli fruits (Cv. Dyavnur)

Treatments	L/B ratio	Sun dried fruits			Moisture in fresh red fruits
		Seed	Pericarp	Pedicel	
		(%)			
T_1 - Control (Water spray at 60 & 90 DAT)	6.96	34.57	58.45	6.98	73.85
T_2 - 5% cow urine spray at 60 DAT	9.43	34.59	57.27	8.14	74.75
T_3 - 10% cow urine spray at 60 DAT	8.39	35.97	55.24	8.79	76.03
T_4 - 15% cow urine spray at 60 DAT	8.64	36.14	55.48	8.38	77.44
T_5 - 5% cow urine spray at 90 DAT	8.09	33.87	56.90	9.23	75.79
T_6 - 10% cow urine spray at 90 DAT	8.62	32.24	59.80	7.96	76.52
T_7 - 15% cow urine spray at 90 DAT	8.65	31.84	59.74	8.42	77.50
T_8 - 5% cow urine spray at 60 & 90 DAT	7.80	34.74	57.17	8.09	75.53
T_9 - 10% cow urine spray at 60 & 90 DAT	8.31	33.51	57.86	8.63	75.24
T_{10} - 15% cow urine spray at 60 & 90 DAT	10.16	30.13	61.57	8.30	76.43
T_{11} - 1% urea spray at 60 DAT	8.78	33.64	57.94	8.42	74.59
T_{12} - 50 ppm NAA spray at 60 DAT	8.10	36.50	55.33	8.17	74.82
S.Em. ±	0.67	1.97	3.58	0.35	0.25
C.D. (0.05)	NS	NS	NS	NS	NS
C.V. (%)	6.54	5.06	6.73	7.50	5.29

DAT - Days after transplanting
RDF - 100:50:50 N, P_2O_5 and K_2O kg ha^{-1} respectively + FYM (25 t ha^{-1}) is common for all the treatments NS - Non-significant

Total dry matter yield (g plant^{-1})

The dry matter output of chilli at 60 DAT was not substantially affected by foliar cow urine spray. This is evident because all treatments received only a uniform dose of fertilizers before 60 DAT (Table 10). As noted in earlier tables of plant height and number of branches, there was no important distinction in treatments with regard to these growth characteristics and consequently dry matter output was also not significantly affected by 60 DAT treatments. The dry matter yield values at 60 DAT closely resemble the values previously reported for Byadgi chilli cultivated on medium black soil by Neelgar *et al.* (2013) [10].

At 75, 105 and 140 DAT, treatment (T_{10}) that received two foliar sprays of cow urine at 15% recorded significantly highest dry matter yield of 58.73, 106.97 and 121.12 g plant^{-1} for 75, 105 and 140 DAT, respectively. This treatment differed significantly from all other treatments with respect to dry matter yield at 105 and 140 DAT. But at 75 DAT, this treatment (T_{10}) was on par with treatments T_4 (55.60 g plant^{-1}), T_{10} (58.73 g plant $^{-1}$) and differed significantly from rest of the treatments. Control (T_1) recorded lowest dry matter yield of 29.35, 39.92 and 61.32 g plant^{-1} at 75, 105 and 140 DAT, respectively, while treatment (T_{12}) with foliar spray of NAA recorded 31.67, 40.92 and 73.52 g plant^{-1} at 75, 105 and 140 DAT, respectively. Data also indicated that treatment that received foliar spray of urea (T_{11}) recorded significantly higher dry matter yield (42.20 & 55.03 g plant $^{-1}$ at 75 & 105 DAT respectively) than treatment with NAA spray (T_{12}). This could be due to the positive impact of particular NPK in urine along with other nutrients provided by foliar spray. These nutrients were absorbed directly either through cuticle or stomata and may have been involved in photosynthesis leading to enhanced output of dry matter. Foliar nutrient spray that has enhanced plant timely and adequate nutrient accessibility and chilli leaves absorption resulting in better nutrient absorption, assimilation and translocation.

Higher potassium levels and growth promoting substances such as oxalic acid, enzymes, crietinine and hipuric acid found in urine led in better use of nutrients to increase the output of dry matter Jadhav *et al.* (2020) [6]. Growth-promoting substances in urine stimulate physiological mechanisms in crops leading to increased cell division, synthesis of chlorophyll, and photosynthesis production. Additional foliar sprays provided at 60 and 90 DAT could have synchronized closely with vegetative and peak flowering phases of chillies resulting in better absorption, translocation and assimilation of NK by chilli plant.

Table 10: Effect of foliar spray of cow urine on dry matter yield of chilli at different days (Cv. Dyavnur)

Treatments	Dry matter yield (g plant^{-1})			
	60 DAT	75 DAT	105 DAT	Harvest
T_1 - Control (Water spray at 60 & 90 DAT)	20.60	29.35	39.92	58.82
T_2 - 5% cow urine spray at 60 DAT	21.09	40.97	47.07	76.73
T_3 - 10% cow urine spray at 60 DAT	21.84	45.87	58.57	83.05
T_4 - 15% cow urine spray at 60 DAT	22.06	55.60	75.83	93.30
T_5 - 5% cow urine spray at 90 DAT	22.18	33.86	62.30	84.25
T_6 - 10% cow urine spray at 90 DAT	20.73	34.55	73.93	87.23

T_7 - 15% cow urine spray at 90 DAT	21.06	35.11	75.57	91.40
T_8 - 5% cow urine spray at 60 & 90 DAT	20.92	41.45	85.91	87.49
T_9 - 10% cow urine spray at 60 & 90 DAT	22.14	46.77	94.40	104.54
T_{10} - 15% cow urine spray at 60 & 90 DAT	22.09	58.73	106.97	121.12
T_{11} - 1% urea spray at 60 DAT	21.08	42.20	55.03	82.60
T_{12} - 50 ppm NAA spray at 60 DAT	21.11	31.67	40.92	73.52
S.Em. ±	1.57	1.94	1.65	4.20
C.D. (0.05)	NS	6.25	5.27	13.12
C.V. (%)	8.25	6.59	5.82	10.19

DAT - Days after transplanting
RDF - 100:50:50 N, P_2O_5 and K_2O kg ha^{-1} respectively + FYM (25 t ha^{-1}) is common for all the treatments NS – Non- significant

Fruit yield
Foliar application of 15% cow urine at 60 and 90 DAT (T_{10}) recorded highest fruit yield (14.07 q ha^{-1}) closely followed by treatment (T_9) that received 10% cow urine spray at 60 and 90 DAT (13.06 q ha^{-1}) and treatment (T_4) that received 15% cow urine spray at 60 DAT (11.66 q ha^{-1}). The growth harmones present in cow urine stimulate meristematic tissue in chilli plants which lead to more flower buds and flowering. This might have formed more number of fruits in plants (Table 11). Similar results on increased fruit yield were reported by Sadhukhan *et al.* (2018) [13] in wheat crop, Jadhav *et al.*, in maize and Ansar *et al.*, 2022 [1] in mustard crop. It was noticed that, treatments (T_4, T_7 and T_{10}) that received 15 Percent foliar spray recorded numerically higher fruit yield than treatments that received five (T_2, T_5 and T_8) and ten (T_3, T_6 and T_9) Percent foliar spray. This was due to increased absorption of nitrogen by chilli leaves leading to increased chlorophyll content and photosynthesis. Control (T_1) that received water spray recorded lowest fruit yield (9.68 q ha^{-1}) which was on par with treatment T_{12} that received 50 ppm NAA foliar spray at 60th DAT (9.90 q ha^{1}) as well as treatment (T_{11}) that received urea spray (10.30 q ha^{-1}). This is obvious because of non-availability of N, P and K during flowering and fruit development stages in adequate amount otherwise supplied through urine spray. This has resulted in lower yield attributes.

Table 11: Effect of foliar spray of cow urine on yield parameters and dry fruit yield of chilli (Cv. Dyavnur)

Treatments	No. of fruits/plant/ picking	100 fruit weight (g)	Fruit yield (q ha^{-1})
T_1 - Control (Water spray at 60 & 90 DAT)	16.85	148.80	9.68
T_2 - 5% cow urine spray at 60 DAT	17.50	151.97	10.01
T_3 - 10% cow urine spray at 60 DAT	18.82	154.27	10.55
T_4 - 15% cow urine spray at 60 DAT	21.95	163.10	11.66
T_5 - 5% cow urine spray at 90 DAT	19.20	155.17	10.80
T_6 - 10% cow urine spray at 90 DAT	20.75	161.70	11.30
T_7 - 15% cow urine spray at 90 DAT	21.15	163.17	11.65
T_8 - 5% cow urine spray at 60 & 90 DAT	20.30	160.53	11.25
T_9 - 10% cow urine spray at 60 & 90 DAT	23.13	167.67	13.06
T_{10} - 15% cow urine spray at 60 & 90 DAT	25.78	168.73	14.07
T_{11} - 1% urea spray at 60 DAT	15.85	151.80	10.30
T_{12} - 50 ppm NAA spray at 60 DAT	14.78	148.5	9.90
S.Em. ±	1.27	5.45	0.74
C.D. (0.05)	3.72	16.56	2.17
C.V. (%)	11.15	10.52	11.44

DAT - Days after transplanting
RDF - 100:50:50 N, P_2O_5 and K_2O kg ha^{-1} respectively + FYM (25 t ha^{-1}) is common for all the treatments

Soil analysis after harvest of the crop
The results of the foliar spray of cow urine on soil chemical properties and soil nutrient status after harvest of chilli crop are presented in Table 12 and 13.

pH, EC and Organic carbon
The data presented in Table 12 revealed that, foliar application of cow urine did not significantly influenced the chemical properties of soil of different treatments at harvest (140 DAT). This was mainly due to the common dose of recommended fertilizers applied to all the treatments along with FYM. Further, all treatments received nutrients only through foliar spray and applied nutrients are being absorbed through leaves. There is very little possibility of entrance of these nutrients in soil affecting the soil chemical properties. Hence there was no interaction between the effect of foliar spray of cow urine and soil chemical properties.

Table 12: Effect of foliar spray of cow urine on chemical properties of experimental soil after harvest of chilli (Cv. Dyavnur)

Treatments	pH_w	EC (dS m^{-1})	Organic carbon (g kg^{-1})
T_1 - Control (Water spray at 60 & 90 DAT)	7.14	0.18	6.75
T_2 - 5% cow urine spray at 60 DAT	7.19	0.17	6.56
T_3 - 10% cow urine spray at 60 DAT	7.31	0.14	6.80
T_4 - 15% cow urine spray at 60 DAT	7.47	0.14	7.10
T_5 - 5% cow urine spray at 90 DAT	7.32	0.16	5.80
T_6 - 10% cow urine spray at 90 DAT	7.05	0.13	5.95
T_7 - 15% cow urine spray at 90 DAT	7.29	0.11	6.20

T_8 - 5% cow urine spray at 60 & 90 DAT	7.47	0.18	5.82
T_9 - 10% cow urine spray at 60 & 90 DAT	7.35	0.16	6.78
T_{10} - 15% cow urine spray at 60 & 90 DAT	7.39	0.14	6.59
T_{11} - 1% urea spray at 60 DAT	7.28	0.13	7.15
T_{12} - 50 ppm NAA spray at 60 DAT	7.26	0.12	6.82
S.Em. ±	1.56	0.01	1.21
C.D. (0.05)	NS	NS	NS
Initial values	7.40	0.26	6.90

RDF - 100:50:50 N, P_2O_5 and K_2O kg ha $^{-1}$ respectively + FYM (25 t ha $^{-1}$) is common for all the treatments NS – Non-significant

Table 13: Effect of foliar spray of cow urine on available nutrient status of experimental soil after harvest of chilli (Cv. Dyavnur)

					Ca	Mg
	N	**P_2O_5**	**K_2O**	**S**		
Treatments	**(kg/ha)**				**Exchangeable [cmol (p+) kg $^{-1}$]**	
T_1 - Control (Water spray at 60 & 90 DAT)	253.49	33.56	320.59	30.13	18.51	6.43
T_2 - 5% cow urine spray at 60 DAT	242.32	29.49	309.23	28.00	17.11	6.04
T_3 - 10% cow urine spray at 60 DAT	240.23	26.15	308.59	25.07	16.54	5.80
T_4 - 15% cow urine spray at 60 DAT	220.38	23.14	318.17	20.63	16.23	4.65
T_5 - 5% cow urine spray at 90 DAT	230.67	26.00	306.07	26.29	16.00	5.43
T_6 - 10% cow urine spray at 90 DAT	225.23	25.13	300.09	24.95	18.40	5.65
T_7 - 15% cow urine spray at 90 DAT	223.18	24.19	313.60	22.20	18.19	4.39
T_8 - 5% cow urine spray at 60 & 90 DAT	228.98	25.77	304.11	27.09	18.60	4.19
T_9 - 10% cow urine spray at 60 & 90 DAT	219.17	21.18	323.43	19.80	15.86	3.90
T_{10} - 15% cow urine spray at 60 & 90 DAT	215.43	20.23	298.56	19.20	15.10	3.40
T_{11} - 1% urea spray at 60 DAT	238.52	28.29	310.67	26.13	17.24	6.10
T_{12} - 50 ppm NAA spray at 60 DAT	249.23	30.13	315.29	28.41	17.69	5.95
S.Em. ±	2.71	1.30	3.00	0.85	1.00	0.73
C.D. (0.05)	8.23	4.13	9.01	2.56	3.01	2.15
Initial values	188.65	19.85	290.5	22.0	17.72	5.50

RDF - 100:50:50 N, P_2O_5 and K_2O kg ha $^{-1}$ respectively + FYM (25 t ha $^{-1}$) is common for all the treatments

Available Nitrogen

Foliar spray of cow urine had significant effect on the available nitrogen content in soil at harvest. Control (T_1) that received water spray recorded highest nitrogen content (253.49 kg ha^{-1}) which was on par with treatment (T_{12}) that received 50 ppm NAA spray on 60th DAT (249.23 kg ha^{-1}). Lowest value (215.43 kg ha^{-1}) was recorded in the treatment (T_{10}) that received foliar sprays of 15 Percent cow urine on 60 + 90 DAT which was on par with treatments T_9 (219.17 kg ha^{-1}), T_4 (220.38 kg ha^{-1}) and T_7 (223.18 kg ha^{-1}) but differed significantly from the remaining treatments. This was because of very low dry matter yield in these treatments resulted in low N uptake from soil. Further, higher levels of N supplied through foliar spray of cow urine might have enhanced N uptake because of increased dry matter yield (Sharma *et al*., 2016) [16]. This has resulted in low available N content in soil at harvest.

It was observed that, treatments that received 5 Percent foliar spray recorded higher available nitrogen in soil than treatments which received 10 and 15% foliar spray of cow urine. Low dry matter yield of plants in five Percent foliar spray treatments has resulted in reduced N uptake, indirectly showing high available nitrogen in soil at harvest.

Lowest value (215.43 kg ha^{-1}) was recorded in the treatment (T_{10}) that received foliar sprays of 15% cow urine on 60 + 90 DAT. This was due to highest dry matter yield in this treatment. Veerendra Patel (2014) [21] reported that, available nitrogen content in soil at harvest is greatly influenced by foliar spray of mono potassium phosphate.

Available phosphorus

Available phosphorus was also considerably affected by foliar cow urine spray, similar to nitrogen status. The lowest available phosphorus (20,23 kg ha^{-1}) was reported in the treatment (T_{10}) which received two foliar applications of 15% cow urine at 60+ 90 DAT which was on par with T_4 (23,14 kg ha^{-1}), T_7 (24,19 kg ha^{-1}) and T_9 (21,18 kg ha^{-1}) but considerably differed from other treatments. This is due to the greater production of dry matter in these treatments that may have taken up more P from the soil for dry matter production (Sharma *et al.*, 2016) [16]. In addition, the synergistic relationship between P and N could have increased soil uptake of P.

Critical observations on the data revealed that, treatments (T_2, T_5 & T_8) which received foliar spray of cow urine at five Percent reported more phosphorus content in soil than those of foliar application of cow urine at 10 and 15 Percent. Foliar spray at 15 Percent level resulted in greater in greater uptake of P from soil because of increased dry matter yield. Veerendra Patel (2014) [21] reported that, foliar application of mono potassium phosphate at 1.5 and 2% level resulted in increased uptake of P from soil leading to lower available P content in soil.

Available Potassium

Available potassium content in soil was significantly influenced by foliar spray of cow urine at harvest. The lowest available potassium (298.56 kg ha^{-1}) was reported in treatment (T_{10}) receiving two 15% cow urine sprays on par with T_6 (300.09 kg ha^{-1}), T_8 (304.11 kg ha^{-1}) and T_5 (306.07 kg ha^{-1}), but considerably different from the remaining treatments. This was due to higher soil uptake of K due to enhanced dry matter output that resulted in higher uptake. In addition, this indeterminate crop's luxury consumption of K has also led in increased soil potassium mining.

Critical observations on the information indicated that medicines (T_2, T_5 & T_8) receiving 5% foliar urine spray from cow urine reported numerically greater potassium content in soil than those receiving 10% and 15% foliar urine spray from cow urine. Foliar spray at a rate of 15 percent led to enhanced soil absorption of K due to enhanced output of dry matter. Veerendra Patel (2014) [21] indicated that mono potassium phosphate foliar spray at a rate of 1.5 Percent and 2 Percent resulted in enhanced soil uptake of K resulting in reduced soil K content.

Available Sulphur

The available sulphur content was significantly affected by frequency and concentration of foliar application of cow urine. Lowest available sulphur (19.20 kg ha^{-1}) was found in the treatment (T_{10}) that received two foliar sprays of 15 Percent cow urine. This was because of higher dry matter yield in this treatment that might have resulted in higher uptake of sulphur from soil. Whereas control (T_1) recorded highest available sulphur (30.13 kg ha^{-1}). This is because of low dry matter production which caused uptake of sulphur from soil, because this treatment was supplied with water spray. Further, treatments (T_4, T_7 and T_{10}) that received foliar spray of cow urine at 15 Percent recorded comparatively lower S content in soil than treatments (T_2, T_5 & T_8) that received cow urine foliar spray at five Percent as well as treatments (T_3, T_6 & T_9) that received cow urine foliar spray at ten Percent level. This was because of higher concentration of amide nitrogen in spray solution utilized for spraying that might have significantly influenced the uptake of sulphur from soil (Sharma *et al*., 2016) [16]. Hence, plants were stimulated to absorb more sulphur from soil to meet their demand because of the role of sulphur in the synthesis of chilli oleoresins. This has resulted in less available sulphur in residual soil.

Exchangeable Calcium

The exchangeable calcium content was significantly influenced by foliar application of cow urine (Table 13). Lowest exchangeable calcium content [15.10 cmol (p +) kg^{-1}] was found in the treatment (T_{10}) that received two foliar sprays of 15 Percent cow urine whereas treatment (T_8) that received five Percent cow urine spray at 60 + 90 DAT recorded highest value [18.60 cmol (p +) kg^{-1}] and was on par with all other treatments except treatment (T_{10}) which received foliar spray of 15 Percent cow urine at 60 + 90 DAT [15.10 cmol (p +) kg^{-1}]. This was because of the role of calcium in cell division that lead to higher dry matter yield in this treatment which stimulated higher uptake of calcium from soil. It can be inferred that both water soluble and exchangeable calcium were absorbed from soil Veerendra Patel (2014) [21]. Hence, it is difficult to conclude about exchangeable calcium status in soil at harvest.

Exchangeable Magnesium

Data presented in Table 13 reported that, exchangeable magnesium content in soil was significantly influenced by foliar spray of cow urine after harvest of crop. Lowest exchangeable Mg content [3.40 cmol (p +) kg^{-1}] was found in the treatment (T_{10}) that received two foliar sprays of 15 Percent cow urine whereas control (T_1) recorded the highest value [6.43 cmol (p +) kg^{-1}] in soil and was on par with all other treatments except treatments T_8, T_9 and T_{10} which recorded magnesium content of 4.19, 3.90 and 3.40 cmol (p +) kg^{-1} respectively. This was due to greater uptake of Mg from soil on account of increased dry matter yield as Mg is a component of chlorophyll (Sharma *et al*., 2016). Lastly no definite increase or decrease in exchangeable magnesium content in soil was observed when compared to initial value [5.50 cmol (p +) kg^{-1}].

Conclusion

Two foliar applications of 15 Percent cow urine one each at 60 and 90 DAT recorded highest fruit yield (14.07 q ha^{-1}) closely followed by two foliar sprays at ten Percent (13.06 q ha^{-1}), further followed by one spray of cow urine at 15 Percent on 60 DAT (11.66 q ha^{-1}). Significantly higher soil nutrients were recorded with two foliar application of 15 Percent cow urine each at 60 and 90 days after transplanting. Irrespective of the concentration and frequency of foliar spray of cow urine, growth and yield of Byadgi chilli has increased with cow urine foliar spray over control.

Acknowledgement

This work was supported in part by the Department of Soil Science and Agricultural Chemistry, University of Agricultural sciences, Dharwad, Karnataka, India.

References

1. Ansar M. Application of cow urine fertilizers to increase the growth and yield of mustard plants (*Brassica rapa* L.). Research on Crops. 2022;23(3):566-573.
2. Bidari BI. Studies on yield and quality of Byadgi chilli (*Capsicum annuum* L.) in relation to soil properties in transitional zone and part of dry zone of North Karnataka [PhD thesis]. Dharwad (India): Univ. Agric. Sci.; c2000.
3. Black CA. Methods of Soil Analysis Part - I. Agronomy monograph, 9. Madison, Wisconsin (USA): American Soc. Agron; c1965.
4. Gupta AK. Practical Manual of Agricultural Chemistry. New Delhi: Kalyani Publishers; c2007. p. 159-166.
5. Jadhav KP. Quality and yield of Byadgi chilli (*Capsicum annuum* L.) as influenced by foliar feeding of calcium nitrate in a Vertisol [MSc (Agri.) thesis]. Dharwad (India): Univ. Agric. Sci.; c2017.
6. Jadhav AB, Marbhal AM, Patil GD, Jadhav AC, Pachpute ST. Effect of Nitrogen and Foliar Sprays of *Cattle Urine* on Growth, Yield and Nutrient Uptake by Maize (Fodder) Grown on Inceptisol. Int. J Curr. Microbiol. App. Sci. 2020;9(5):155-166.
7. Jaiswal PC. Soil, Plant and Water Analysis. Ludhiyana (Panjab): Kalyani Publishers; c2013. p. 339.
8. Janjal PS, Jadhav AB, Patil AV, Pachpute ST. Effect of Soil Application of *Cattle Urine* and Nitrogen on Growth, Yield and Nutrient Uptake by Maize (Fodder) in Inceptisol. Int. J Pl Soil Sci. 2021;33(12):29-24.
9. Natarajan S. Standardization of nitrogen application of chilli grown under semi dry condition. South Indian Hort. 1990;38(6):315-318.
10. Neelgar MN, Bidari BI, Sannagoudra HM, Hebsur NS, Adhoni SM. Studies on foliar feeding of water soluble fertilizers with iron and boron on growth and yield components of red chillies. An Asian J Soil Sci. 2013;8(1):84-87.
11. Pankar DS, Magar NG. Proximate composition and minerals in some selected varieties of red chillies (*Capsicum annuum* L.). J Maharashtra Agric. Univ. 1978;3(1):15-19.
12. Piper CS. Soil and Plant Analysis. Bombay (India): Hans Publishers; c2002. p. 43-56.
13. Sadhukhan R, Bohra JS, Choudhury S. Effect of fertility levels and cow urine foliar spray on growth and yield of wheat. International Journal of Current Microbiology and Applied Sciences. 2018;7(3):907-912.
14. Sadhukhan R, Bohra JS, Sen S. Growth and yield response of rice (*Oryza sativa*) to graded doses of nutrients and foliar spray of cow urine. Indian Journal of Agronomy. 2019;64(1):58-61.

15. Sadhukhan R, Bohra JS, Singh RK, Hasanain M, Sen S, Mondal BP. Integrated nutrient management with cow urine foliar application in wheat (*Triticum aestivum*). The Indian Journal of Agricultural Sciences. 2020;90(3):666-668.
16. Sharma, Shah SC, Adhikari KR, Shah P, Shrestha J. Effects of cattle urine and FYM on yield of broccoli and soil properties. J Agri. Search. 2016;3(3):157-160.
17. Sparks DL. Methods of Soil Analysis Part-3: Chemical Methods. USA: Soil Science Society of America; c1996. p. 21.
18. Subbaiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956;25:259-260.
19. Tandon HLS. Methods of Analysis of Soils, Plants, Water and Fertilizers. Fertilizer Development and Consultation Organization. 1998;31:9-16.
20. Thamhane RV, Motiramani VP, Bali YP, Donahue RL. Manures, compost, green manure, saw dust and sewage. In: Soils, their chemistry and fertility in tropical Asia. Ed. 2nd. New Delhi: Prentice Hall of India, Pvt. Ltd.; c1965. p. 278-285.
21. Veerendra Patel GM. Influence of mono potassium phosphate fertilizer application on yield and quality of Byadgi chilli (*Capsicum annuum* L.) in a Vertisol of northern transitional zone of Karnataka [MSc (Agri.) thesis]. Dharwad, Karnataka (India): Univ. Agric. Sci.; c2014.